

COW CREEK AQUIFER REMEDIATION PROJECT

GEOLOGY & WELL TECHNOLOGY SECTION FALL 2015 SEMINAR

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COW CREEK AQUIFER REMEDIATION PROJECT

- *Preliminaries:*

- a.k.a. “American Salt Site”
- Sodium & chloride (Brine) contamination in groundwater from historical mineral mining/production
- A long-term groundwater remediation project
- Projected 35- to 50-year cleanup timeframe

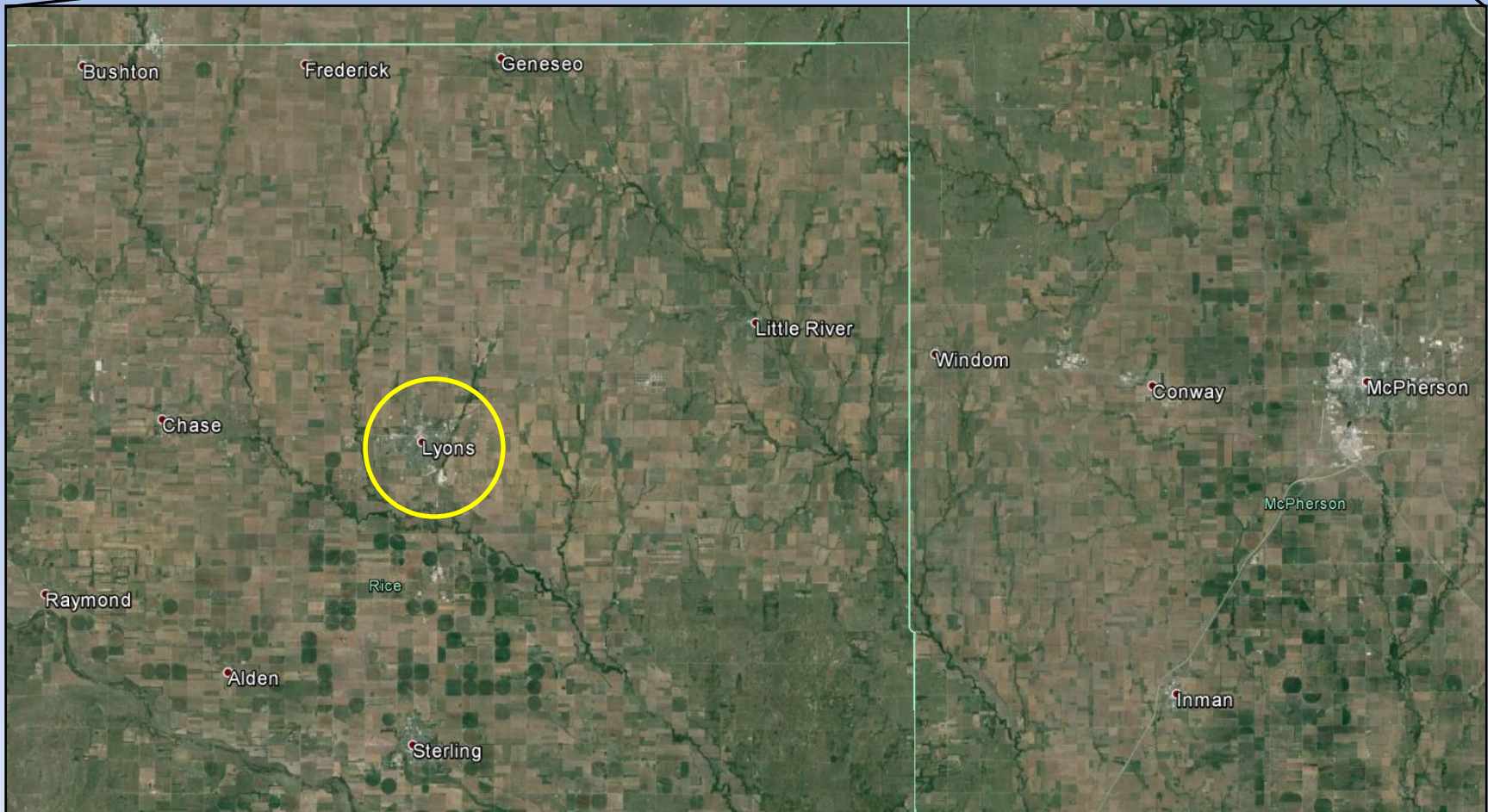
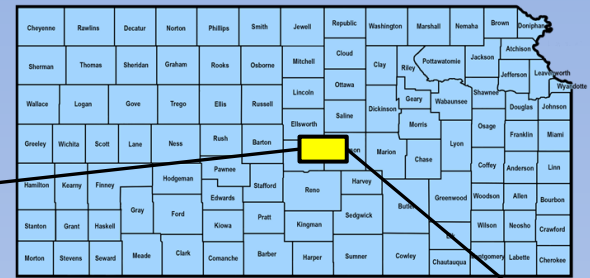
COW CREEK AQUIFER REMEDIATION PROJECT

Preliminaries continued:

- Relation to project (~ 20+ years):
 - KDHE Project Manager 1993 – 2006 (~ 14 years)
 - Consulting support 2009 to present (~ 7 years)

- Site characterization, remedial design & implementation done prior to 1988

Lyons, Rice County, Kansas

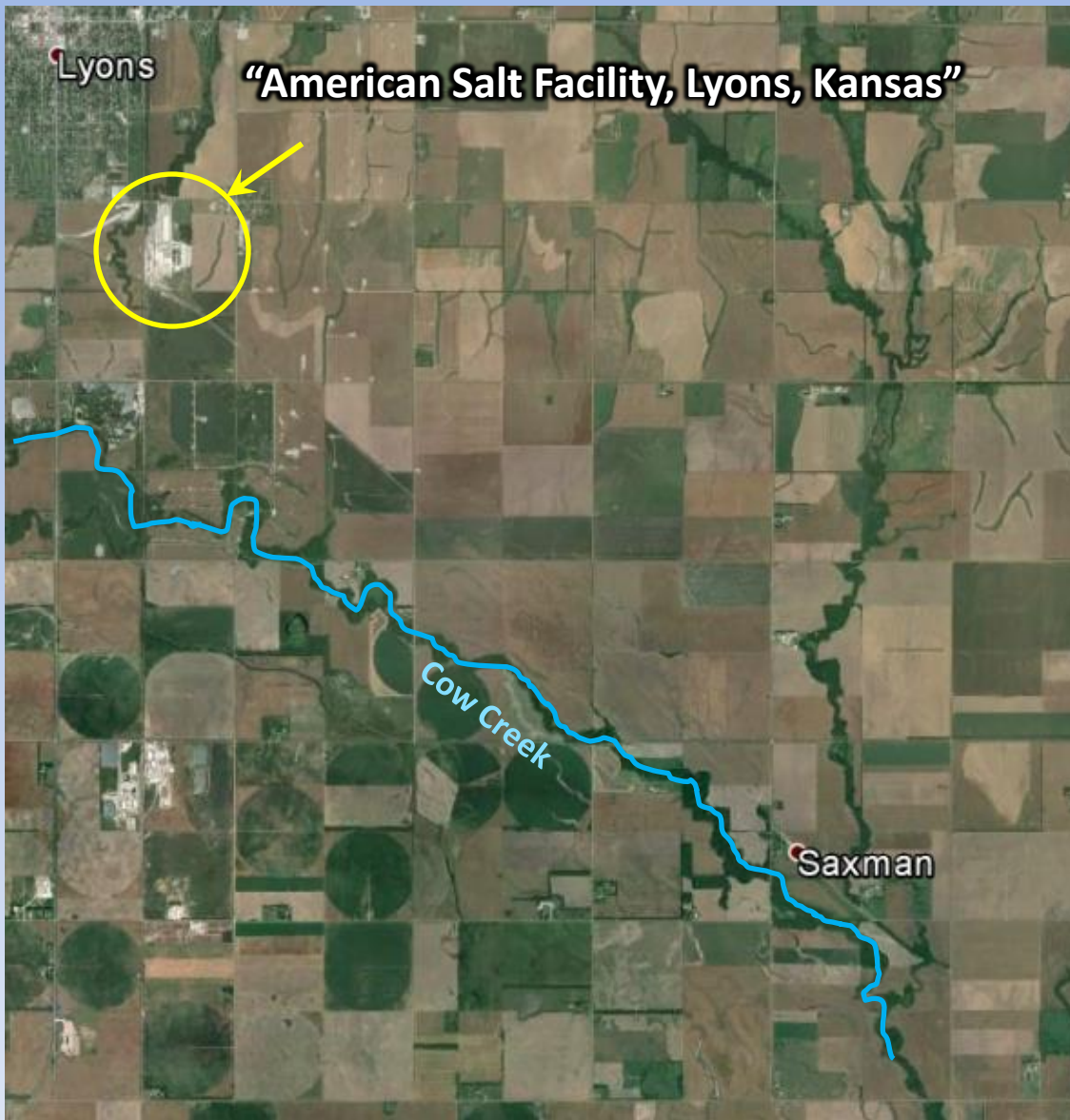


Aerial: Google Earth™ - imagery 6/19/2015

Locality

Features:

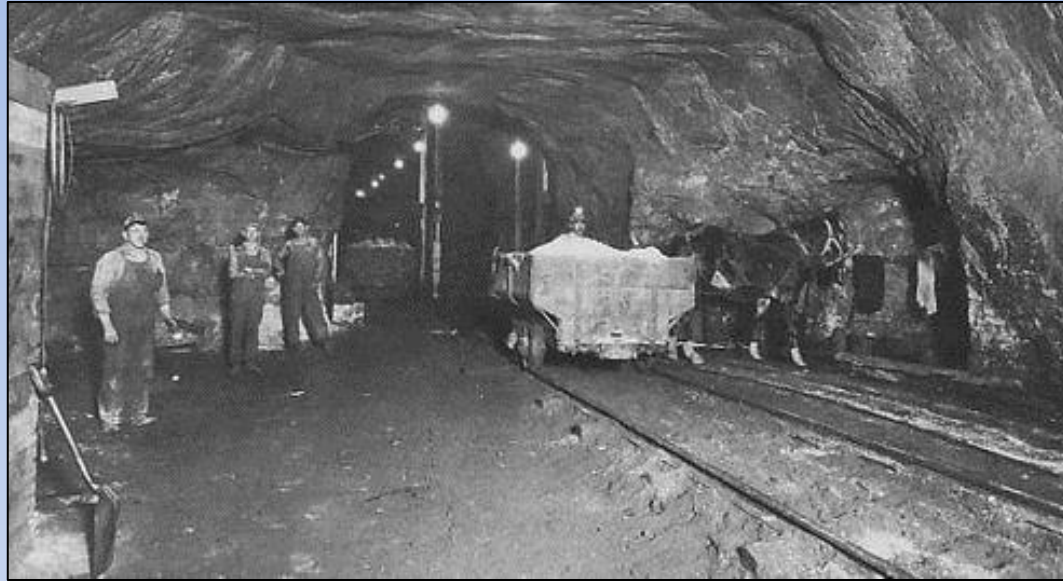
- Lyons, KS
- American Salt Plant & Mine
- Cow Creek
- Saxman, KS



Aerial: Google Earth™ - imagery 6/19/2015

HISTORY

- Solution and hard-rock salt mining at site location southeast of Lyons began before 1918
- Operations in 1980s by American Salt Company (thus the site name)
- Around 1990, the hard rock mining operation was sold, and solution mining currently operated by Compass Minerals Americas, Inc.



American Salt and Coal Company, Lyons, Kansas (photo - www.miningartifacts.org)

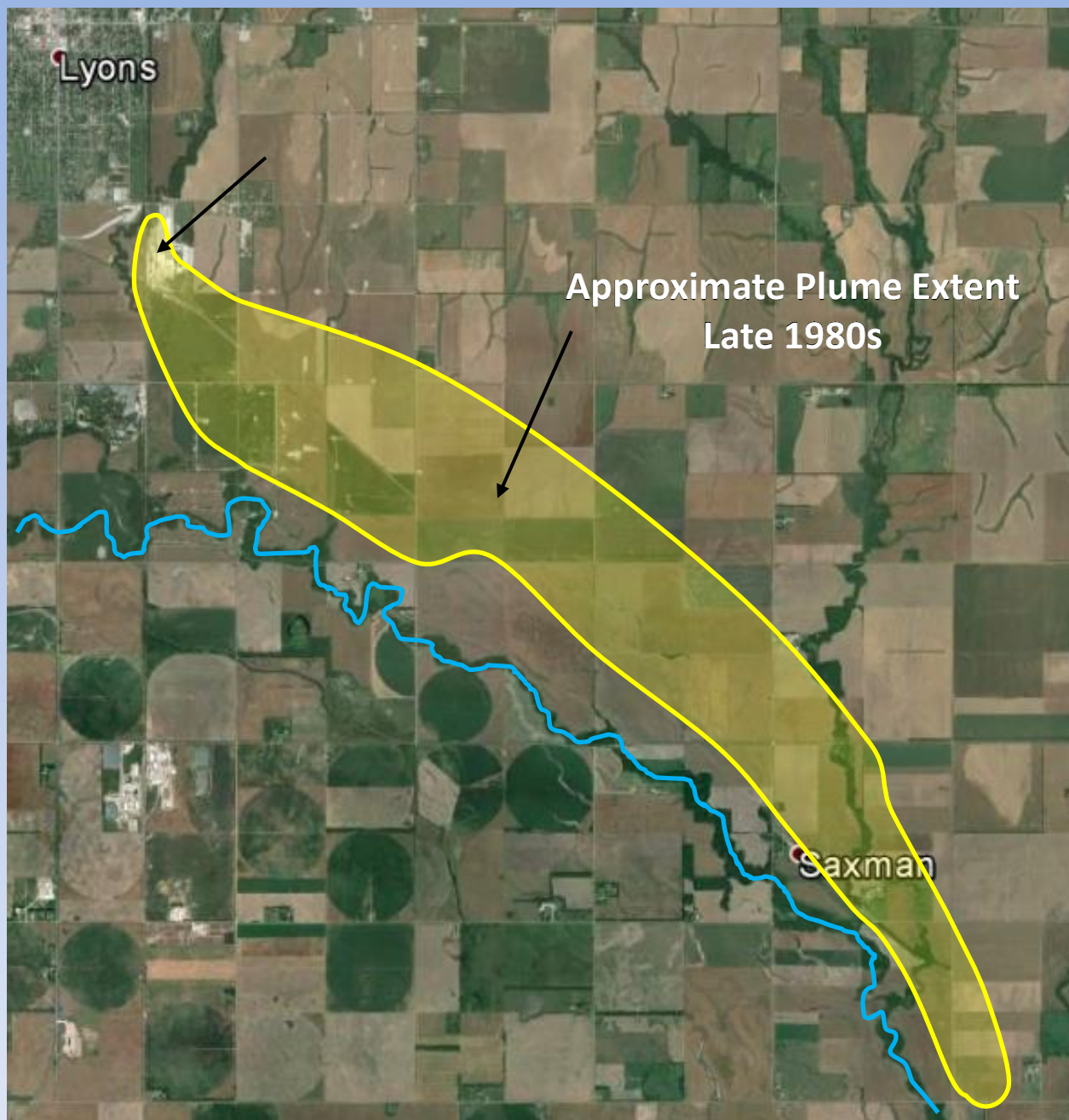
HISTORY

- Order on Appeal executed between American Salt Company and KDHE in 1987
- Established many requirements for implementation, including but not limited to:
 - Remediation (groundwater) targets of 250 mg/L for chloride, and 100 mg/L for sodium
 - Groundwater monitoring with annual reporting to KDHE
 - Groundwater modeling with on-going review



CHARACTERIZATION

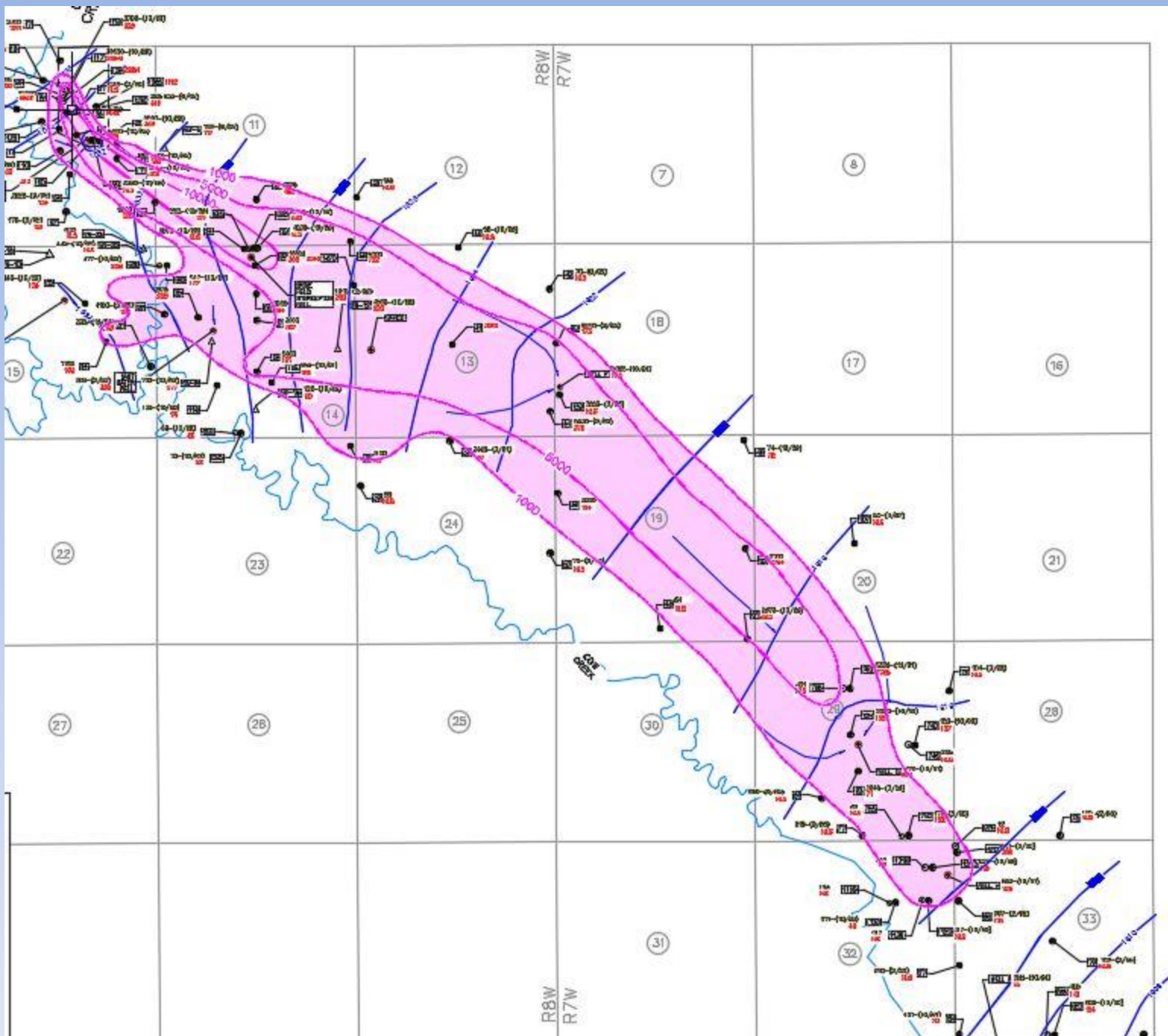
- Characterization began in the early 1980s
- Over 170 monitoring wells installed (most in 1984 through 1987)
- Characterization of extent of impact completed by late 1980s



Aerial: Google Earth™ - imagery 6/19/2015

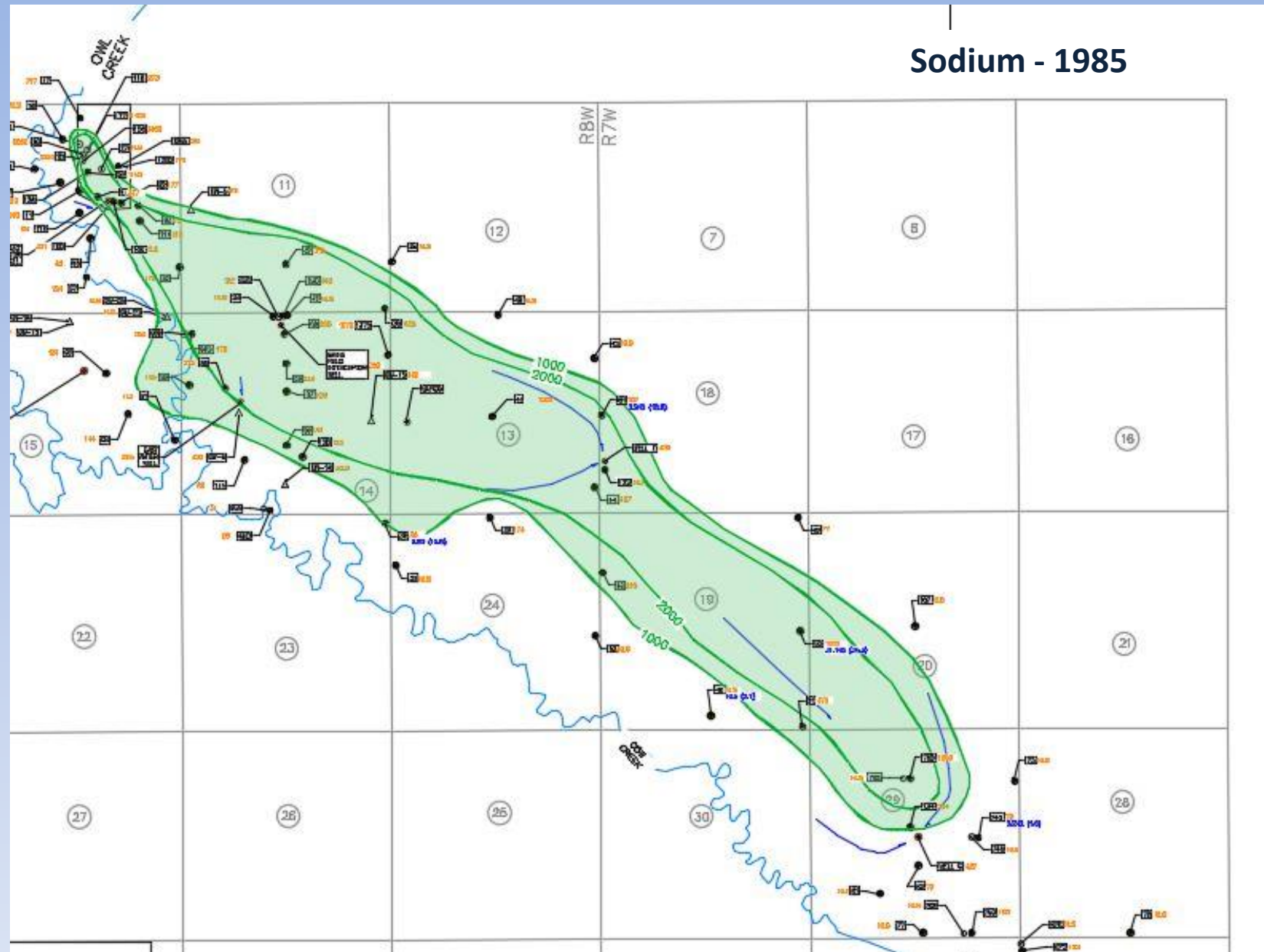
General Extent

- Chloride and sodium plumes
~ 7 miles long
~ 1/2 to 1 mi. wide
- $\text{Cl} > 10,000 \text{ mg/L}$
- $\text{Na} > 2,500 \text{ mg/L}$
- Plumes highly stratified away from plant



Chloride - 1984

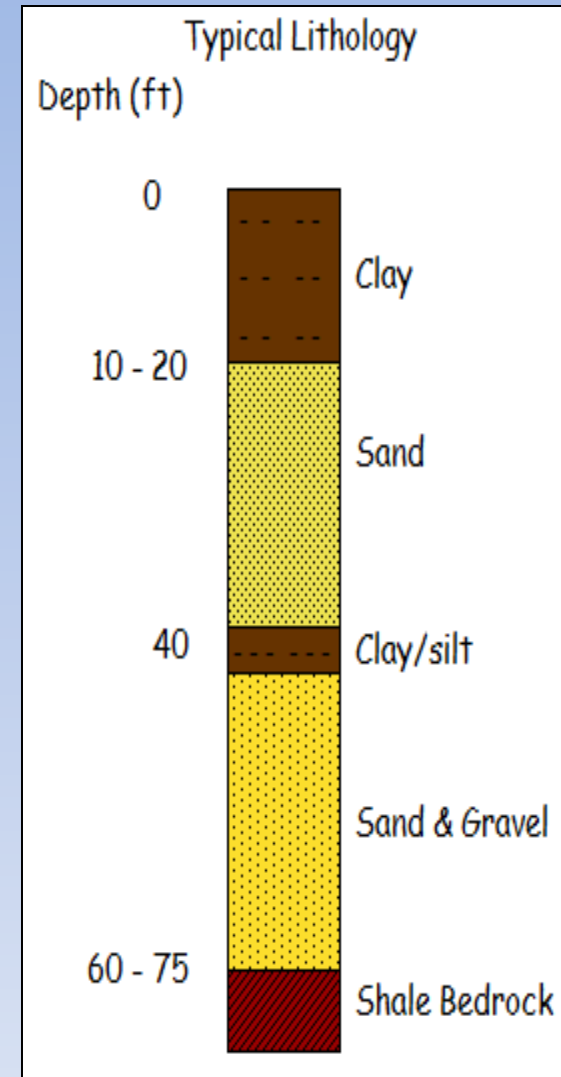
Sodium - 1985



AREA GEOLOGY

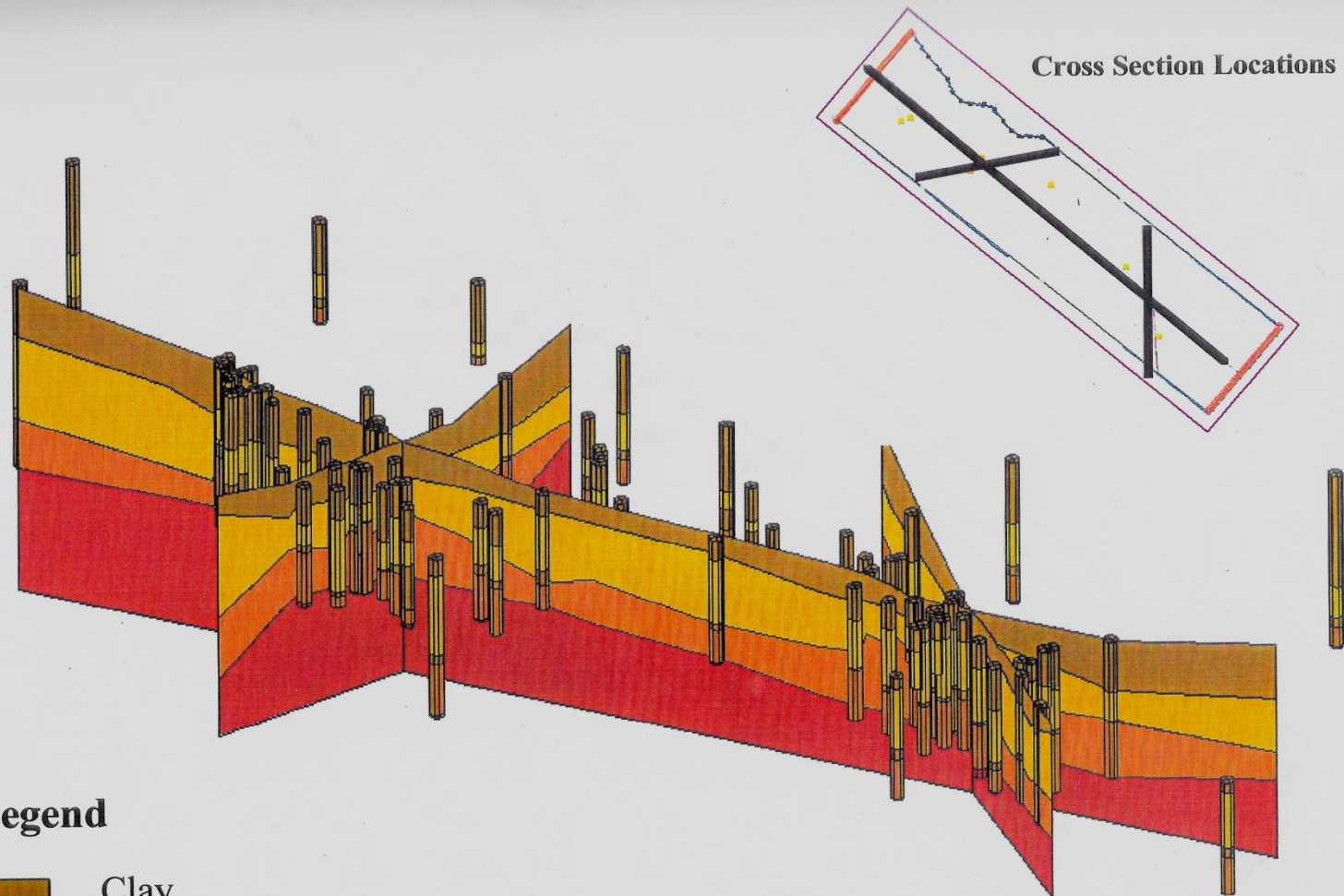
➤ Cow Creek Alluvial Terrace Deposits

- Unconsolidated clay, sand and gravel ranging from 60 to 75 feet thick
- Clay present in upper 10 to 20 feet, underlain by sands and gravel to bedrock
- Underlying bedrock is Permian shale
- Fairly continuous clay/silt layer observed about 40 feet below land surface present







AREA HYDROGEOLOGY

- Groundwater is shallow – averaging < 20 feet from surface
- Saturated thickness ranges from 40 to 60 feet
- Groundwater flow is to the southeast, parallel to Cow Creek
- Average gradient ≈ 0.00076 ft/ft, with a head drop over the 6.9-mile plume extent of 30 to 35 feet
- Upper and lower aquifer zones (separated by clay/silt layer at approximately 40 feet below land surface)



Legend

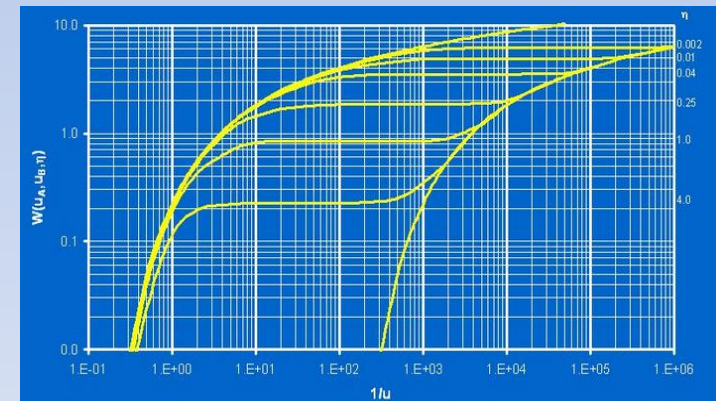
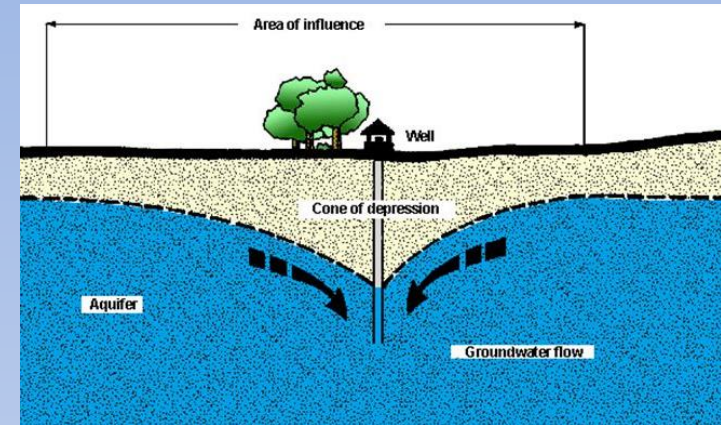
-  Clay
-  Upper Aquifer
-  Lower Aquifer
-  Shale

Geological Fence Diagram

Figure 2

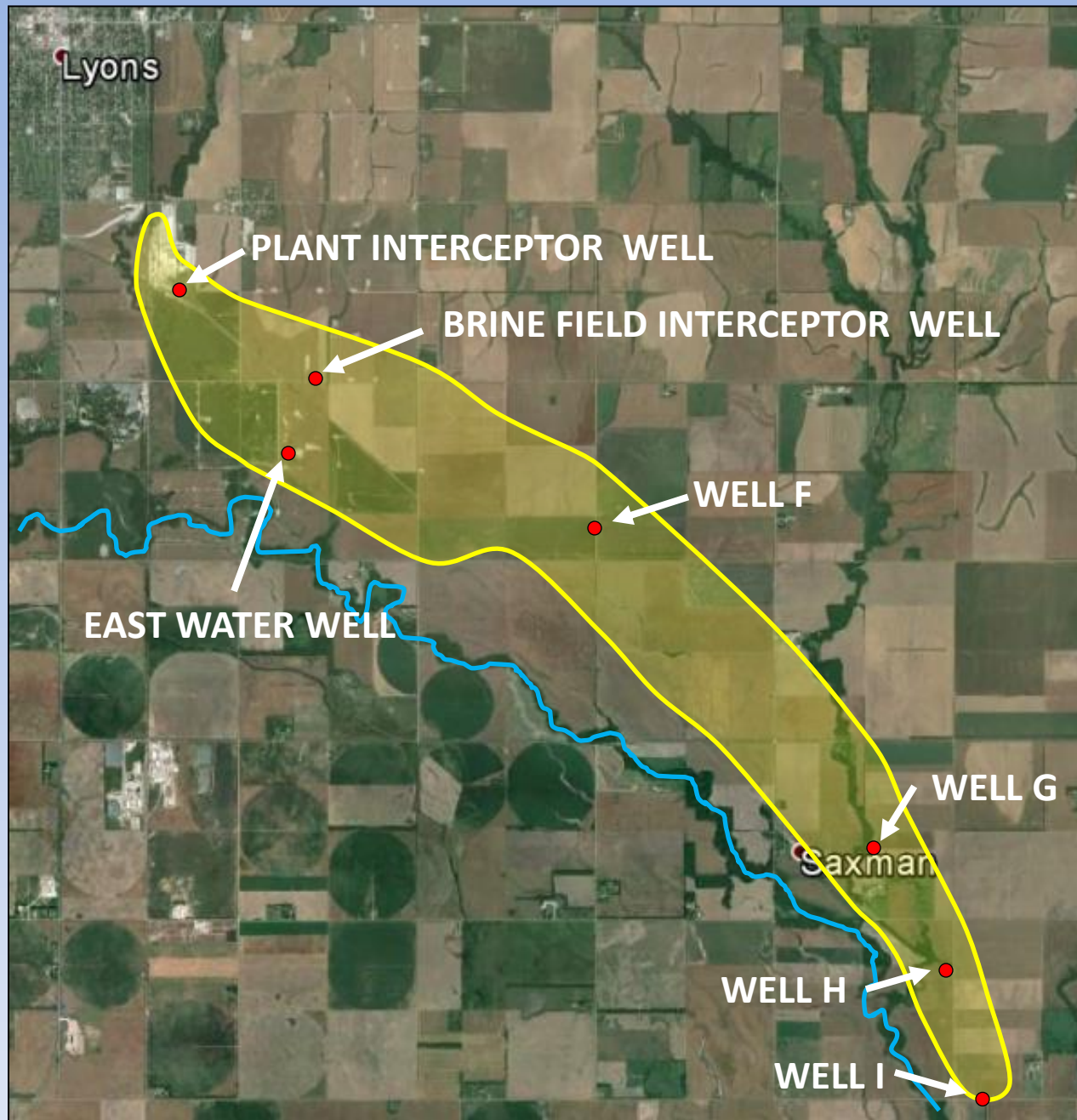
AQUIFER TESTING

- Pumping tests conducted in 6 areas of the plume
- Aquifer very permeable:
 - Hydraulic conductivity 185 ft/day near Plant
 - 240 ft/day for the majority of the plume length
 - Specific yield increased from 0.1/0.2 to 0.5+ moving downgradient
- Aquifer data used for capture zone analysis and modeling



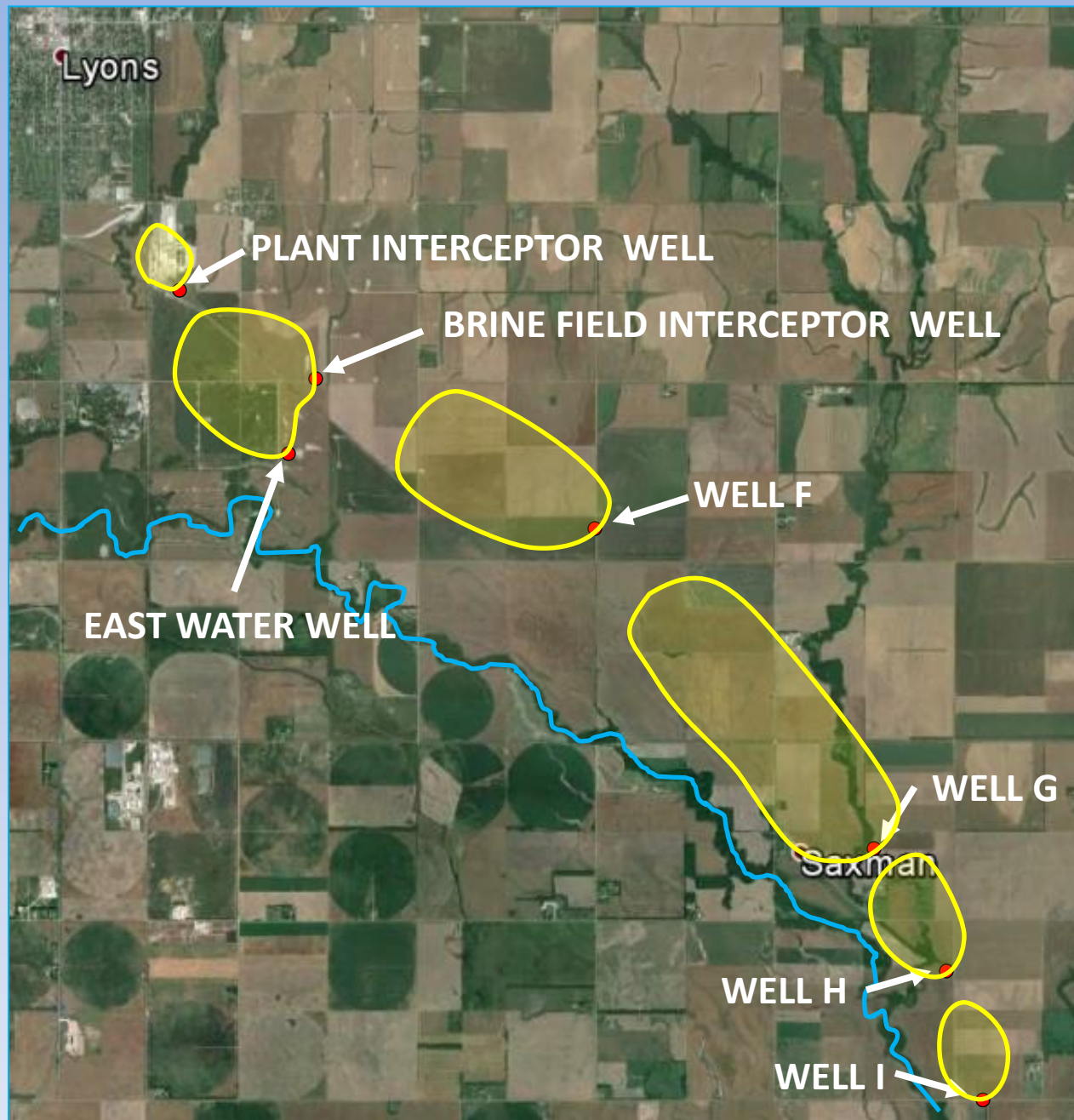
GROUNDWATER MODELING

- Initial modeling performed in 1988, and updated and recalibrated in 1991
- Used PLASM and Random Walk model codes
- Modeling used to project plume remediation rates
- 1999 – remodeled using MODFLOW and MT3D
- The 1999 results were consistent with predictions from the 1991 recalibrated projections
- Overall projections were an approximate 50-year cleanup timeframe



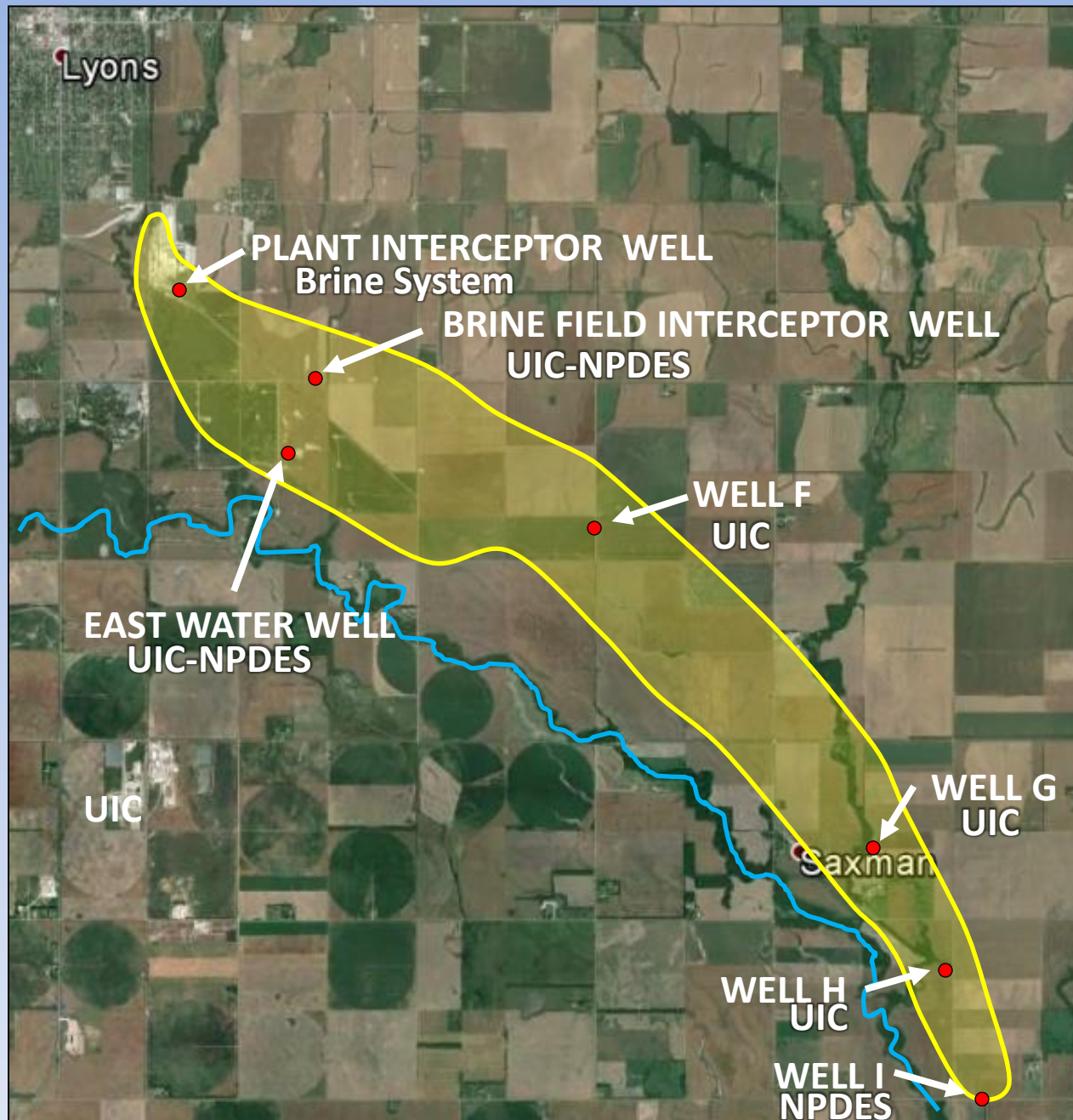
REMEDIAL APPROACH

- **Interceptor Wells**
 - New wells
 - Existing wells
- **Contain plumes**
- **Remove mass**
- **“Pinch off” at wells**



REMEDIAL APPROACH

- Separation into plume segments
- Cleanup time dictated by segment-specific travel time (concentrations, chloride versus sodium, etc.)
- Well location limitations - access



REMEDIAL APPROACH

What to do with
pumped brine?

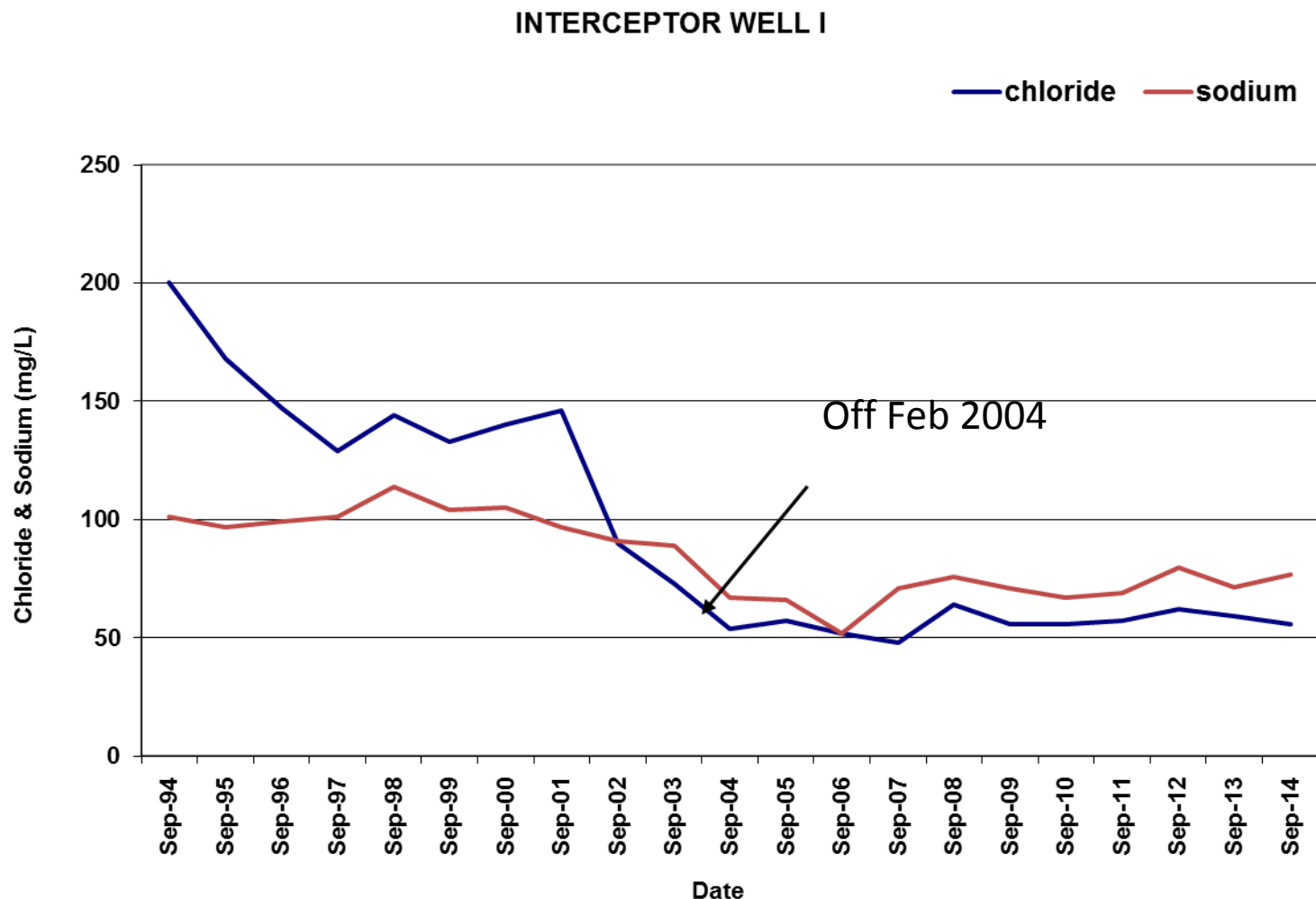
- UIC Class I Non-hazardous injection
- NPDES - surface water discharge to Cow Creek
- UIC then NPDES as levels reduce
- Use for brinefield make-up water

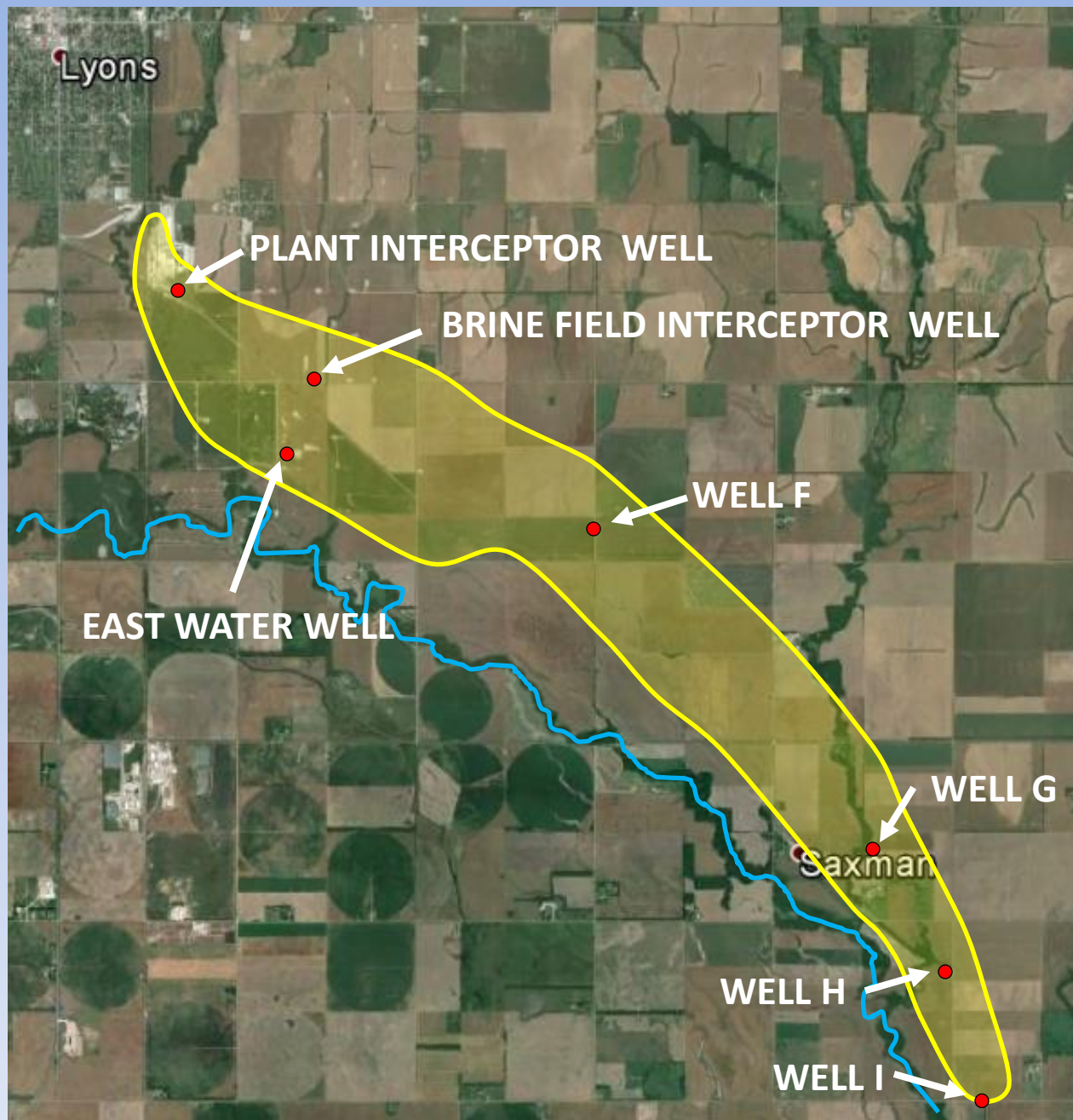
REMEDIATION

- Interceptor wells all installed and operating by 1989
- Four Class I Non-hazardous UIC Wells installed
- Semi-annual groundwater monitoring (relaxed to annual monitoring currently)
- Annual progress reporting and meetings with KDHE
- Routine O&M, settling in for the long haul (50 years)
- Perched zone pumping near Plant

REMEDIAL PROGRESS

- Well I turned off February 2004





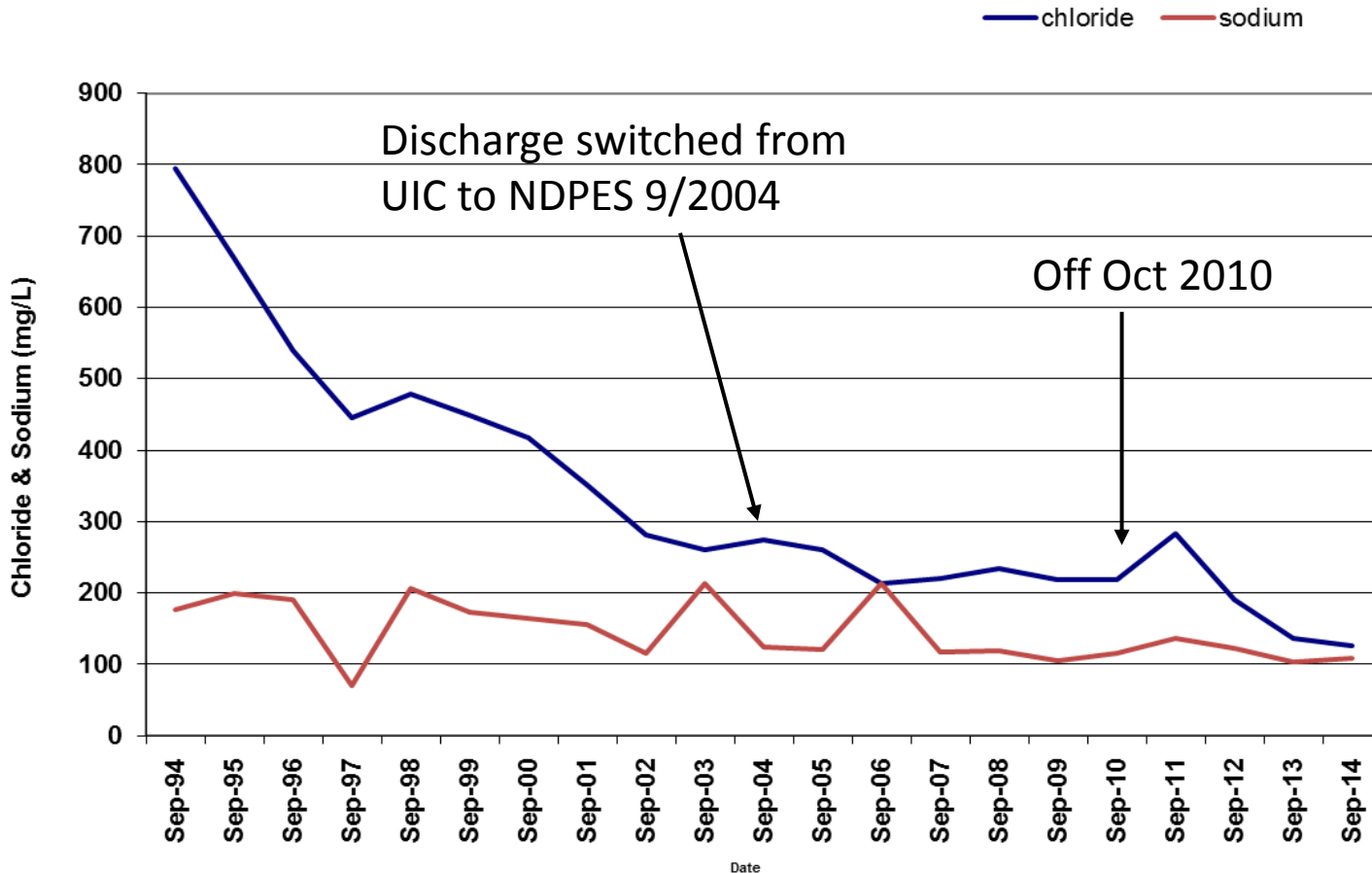
REMEDIAL APPROACH

- Interceptor Wells
 - New wells
 - Existing wells
- Contain plumes
- Remove mass
- “Pinch off” at wells

REMEDIAL PROGRESS

- Well H turned off October 2010

INTERCEPTOR WELL H

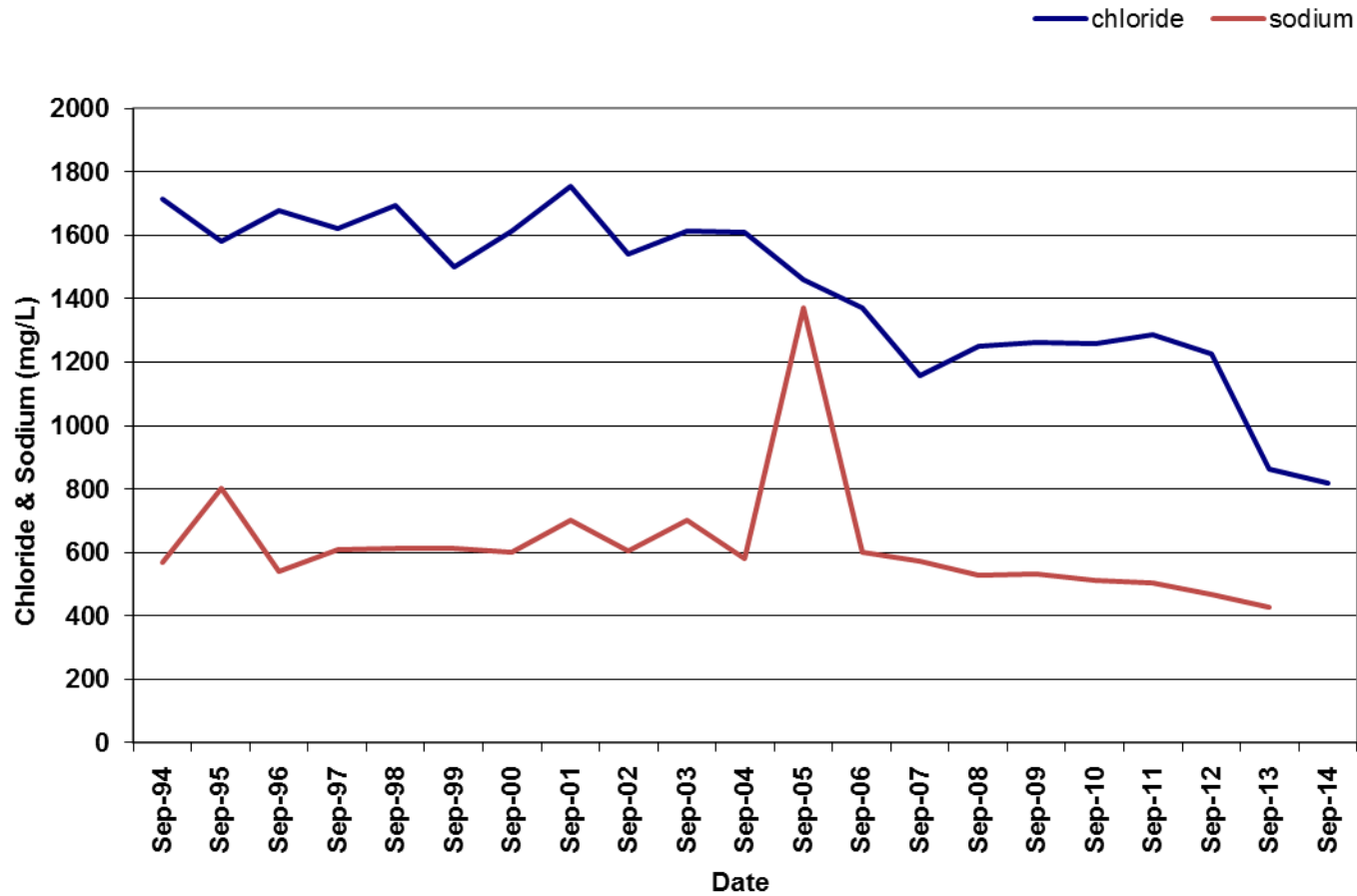


REMEDIAL PROGRESS

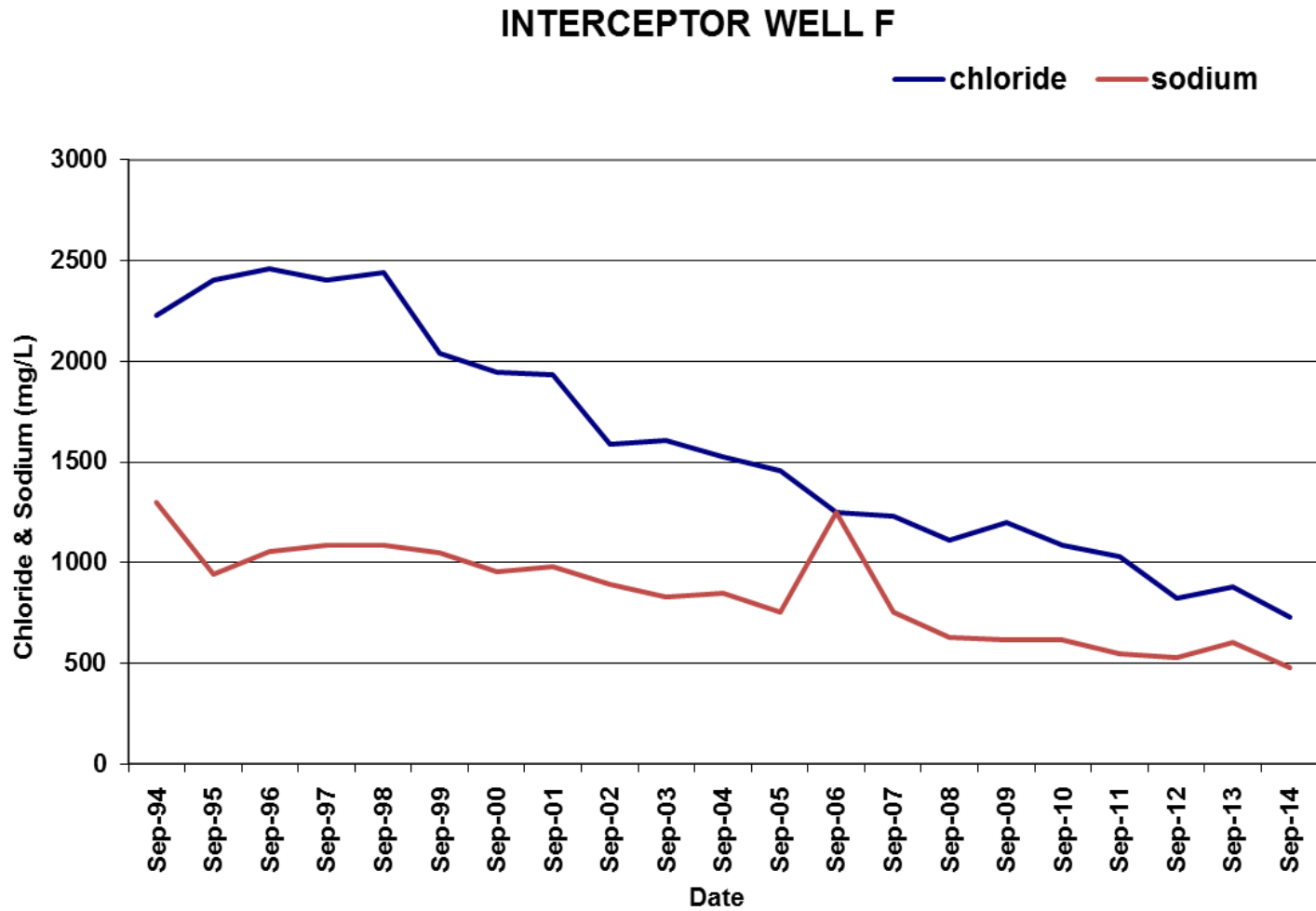
- Plume segments from Wells G to H and from H to I have been effectively remediated
- Post remedial monitoring in these areas
- Well I operated about 17 years (1987 to 2004)
- Well H operated about 24 years (1986 to 2010)
 - Well H disposal was via deep disposal well, but was switched to surface water discharge via Cow Creek NPDES in Sept 2004
 - Chloride dropped in Well H from over 750 to 274 mg/L in 2004 when switched to Cow Creek discharge

MORE REMEDIAL PROGRESS

INTERCEPTOR WELL G

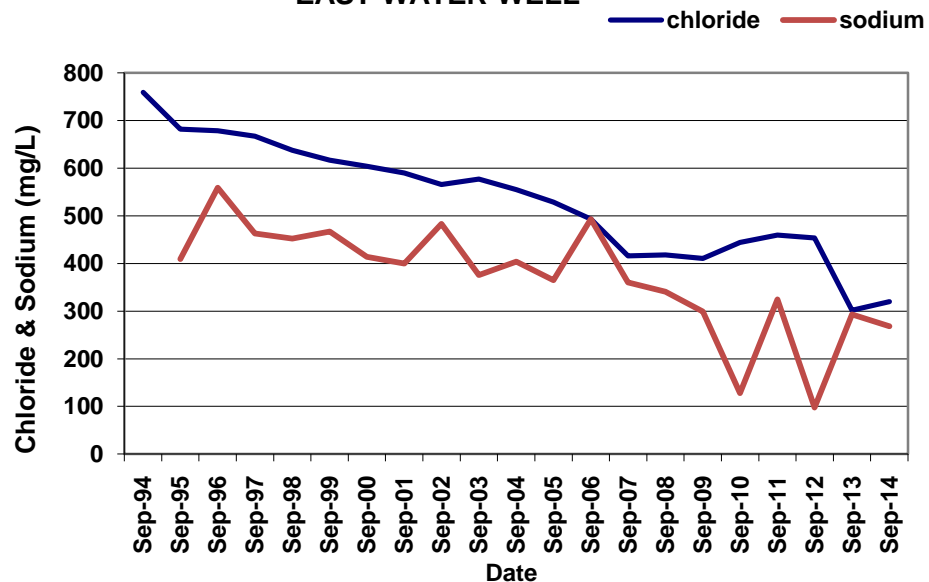


MORE REMEDIAL PROGRESS

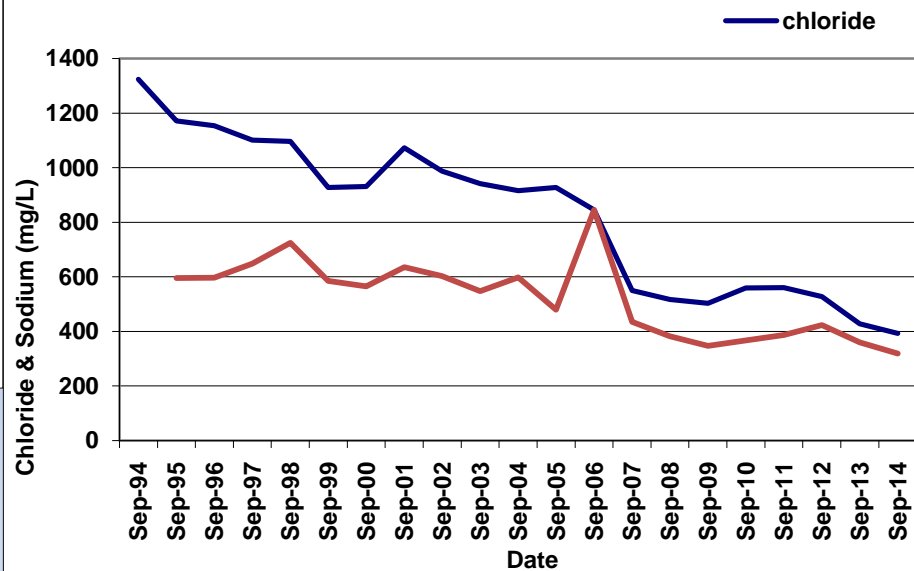


MORE REMEDIAL PROGRESS

EAST WATER WELL

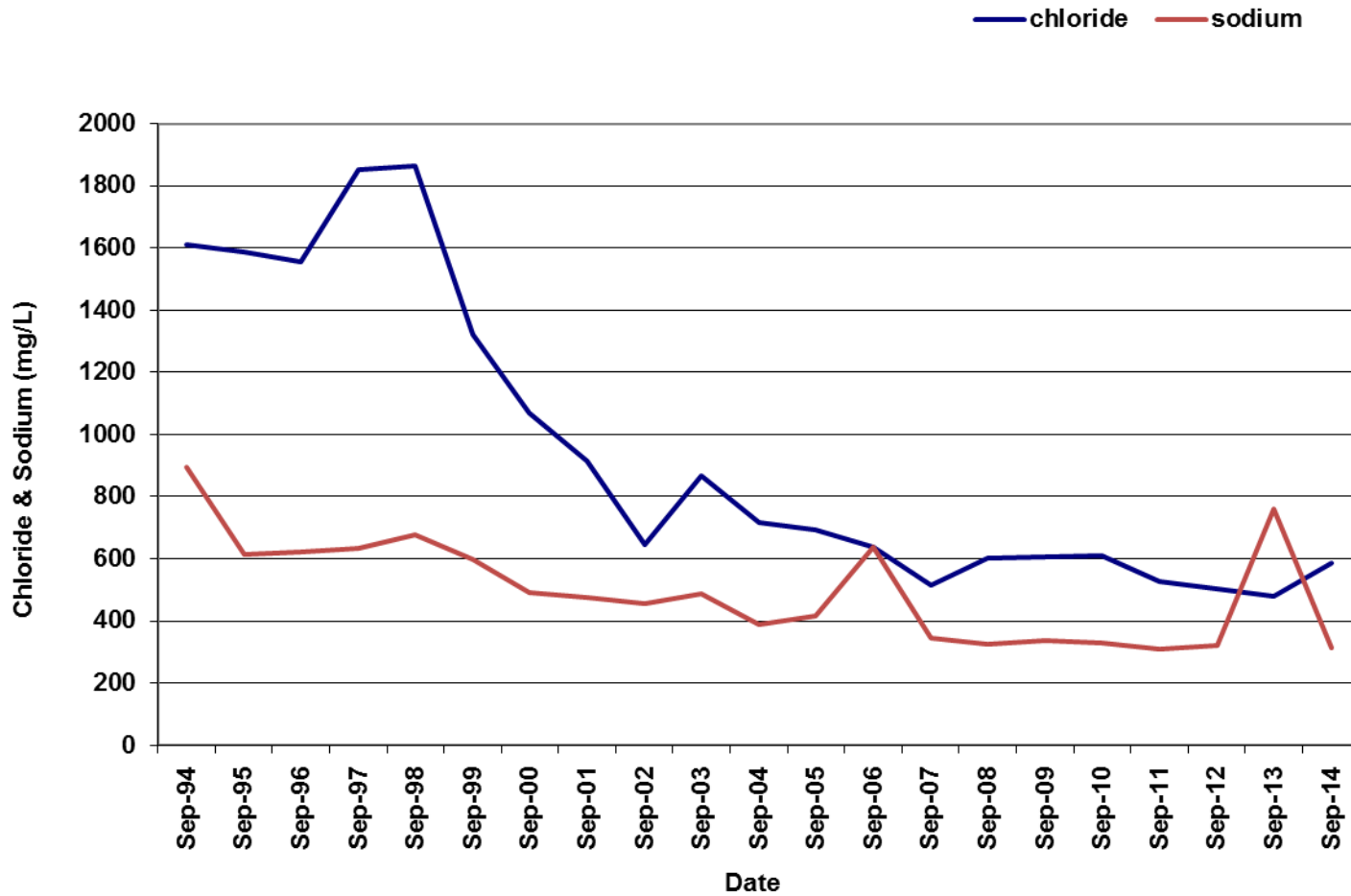


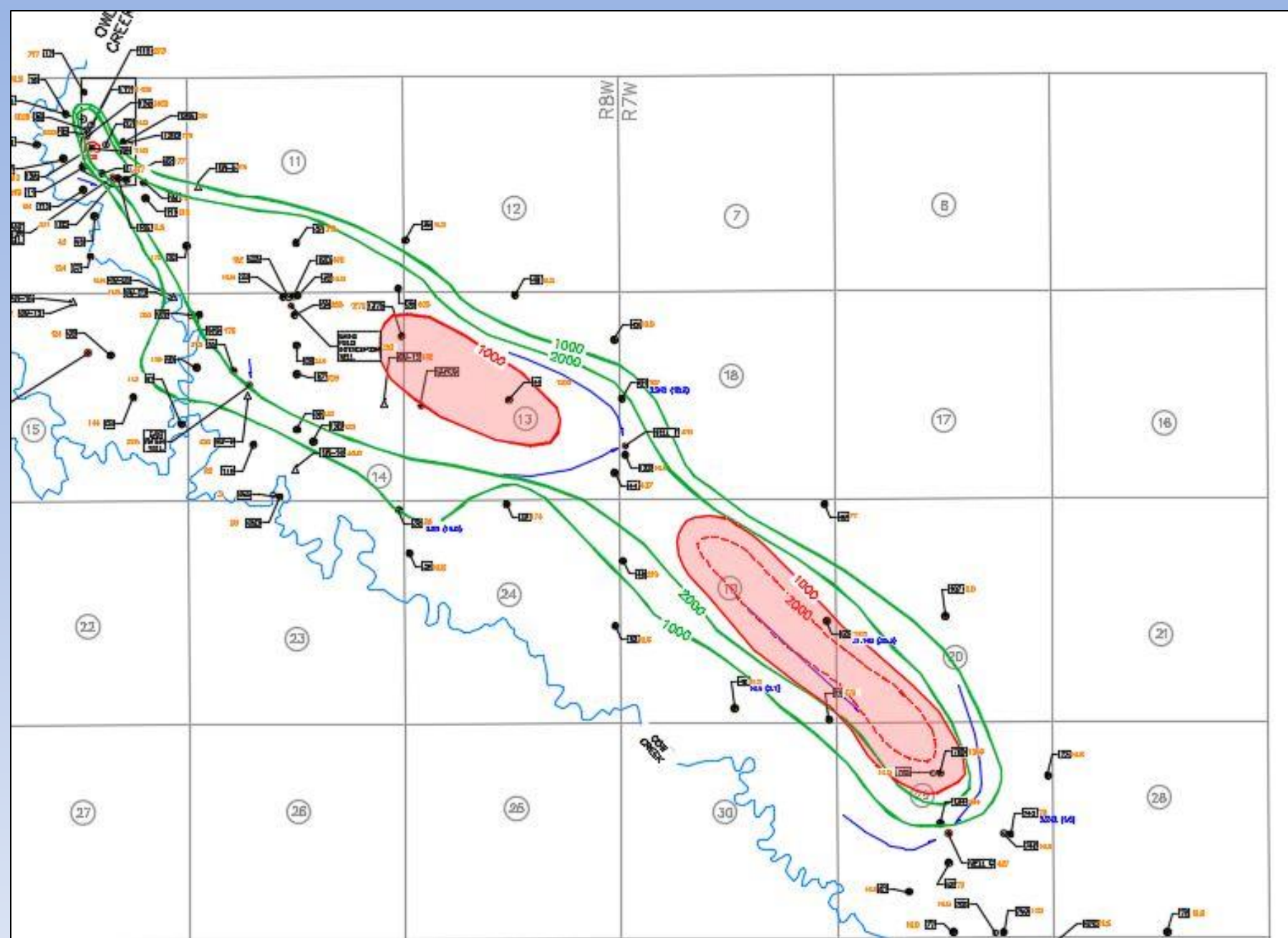
BRINEFIELD INTERCEPTOR WELL

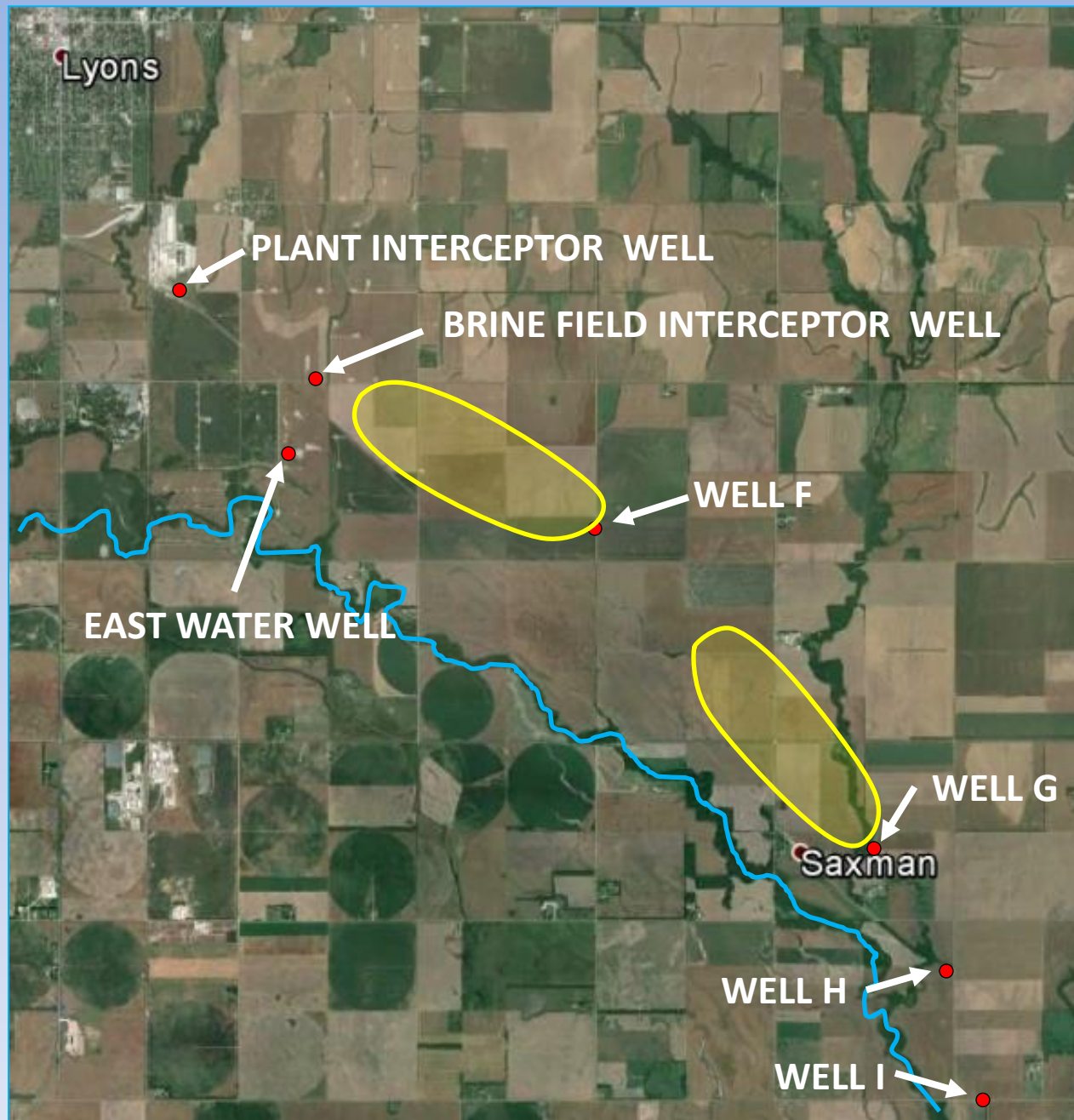


MORE REMEDIAL PROGRESS

PLANT INTERCEPTOR WELL







SUCCESS!

- Areas with > 1000 mg/L shown
- Only 2 of the original 6 segments have deep chloride and sodium above 1,000 mg/L
 - BFI/EWW to F
 - F to G

REMEDIAL PROGRESS

- Currently, no deep monitoring wells with chloride concentrations greater than 5,000 mg/L
- No concentrations of sodium greater than 2,000 mg/L
- Milestones predicted by modeling close to observed progress
 - Plume between G and I remediated by 2006: Segment H to I completed prior to 2004, and G to H was below 250 mg/L by 2006
 - Chlorides below 5,000 mg/L by 2006: achieved by 2001/2002 (minor one time spikes, but otherwise met)
 - Last segment to be remediated will be between Wells F and G

The End!

